Remarks

Claims 1-32 are currently pending in the Application and Claims 33-35 are newly presented herein, withdrawn Claims 12-21 and 27-32 are herein canceled without prejudice, and withdrawn Claims 3-4 and 8 remain as they depend from elected Claim 1, which, for the reasons stated in this response, is expected to be allowed by the Examiner.

Hence, Applicants expect withdrawn Claims 3-4 and 8 to be allowed if the Examiner finds Claim 1 to be allowable.

Summary of claim amendments

This response cancels withdrawn Claims 12-21 and 27-32 without prejudice, expressly reserving the right to present these or any other rejected claims or claims directed to other disclosed subject matter in a future divisional or continuation application.

New Claims

This response adds new Claims 33-35 to more completely claim the invention. Support for the new Claims 33-35 can be found, for example, in the original Claims 1, 6 and 22.

In view of the canceled Claims 12-21 and 27-32, Applicants submit that no excess claim fees are due at this time.

35 U.S.C. §103(a) Rejection

Claims 1-2, 5-7, 9-11 and 22-26 stand rejected under 35 U.S.C. §103(a) as being obvious in view of Claydon (U.S. Publ. No. 2004/0126050) and further in view of Ibsen (U.S. Patent No. 7,085,492).

Applicant submits that the Examiner has not established a prima facie case of obviousness for the claims rejected under 35 U.S.C. §103(a) because the Examiner has failed to show that Claydon and Ibsen teach each and every element as claimed in the present application.

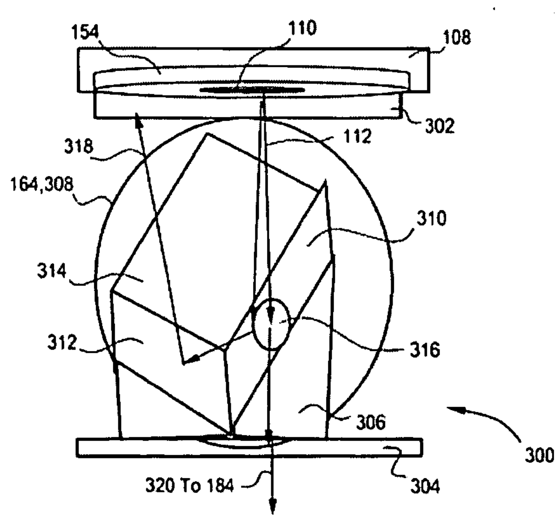
Claim 1

A. Applicants submit that the Examiner has not shown that Claydon and Ibsen disclose, suggest or teach, *inter alia*, the following features recited by Claim 1 of the present application:

> "a retro-reflecting **Fabry-Perot structure** including a pair of reflective surfaces" (emphasis added)

Referring to Claydon's Figure 14, reproduced below, the Examiner asserts that the "Fabry-Perot structure" as recited in Claim 1 is disclosed by Claydon's structure "164" (p. 2, section 2, ll. 4-5). The Examiner further asserts that Claydon's surfaces "310, 312, 314" disclose "a pair of reflective surfaces" as recited in Claim 1. Applicants respectfully traverse the Examiner's assertion.

FIG. 14



According to Claydon, the surfaces "310, 312, 314" are orthogonal to each other (Fig. 14 and paragraph [0041], ll. 2-3 of Claydon). Contrary to Claydon, as known in the industry, the reflective surfaces of the "Fabry-Perot structure" as recited in Claim 1 are parallel to each other, **not** orthogonal as disclosed by Claydon. Enclosed are partial copies of two U.S. Patents 5,208,886 and 5,062,684 and a partial copy of the Encyclopedia of Lasers and Optical Technology that show that the reflective surfaces of the "Fabry-Perot structure" as known in the art are parallel to each other.

Applicants submit that the Examiner failed to comply with 37 C.F.R. §1.104(c)(2) which states:

> "In rejecting claims for want of novelty or for obviousness, the examiner must cite the best references at his or her command. When a reference is complex or shows or describes invention other than that claimed by Applicant, **the particular part relied on must be designated as nearly as practicable**. The pertinence, if not apparent, must be clearly explained and each rejected claim specified" (emphases added).

Applicants submit that the Examiner has failed to "designate as nearly as practicable" where Claydon's surfaces "310, 312, 314" are parallel to each other.

Applicants submit that the Examiner has failed to establish a *prima facie* case of obviousness for the claims rejected under 35 U.S.C. §103(a). Therefore, Applicants respectfully request that the rejection be withdrawn.

B. Applicants submit that the Examiner has not shown that Claydon and Ibsen disclose, suggest or teach, *inter alia*, the following features recited by Claim 1 of the present application:

> "a **micromechanical device** for moving at least one of the reflective surfaces" (emphasis added)

Referring to Claydon's Figure 14, reproduced above, the Examiner asserts that the "micromechanical device" as recited in Claim 1 is disclosed by Claydon's electrostatic actuator (p. 2, section 2, l. 6). Applicants respectfully traverse the Examiner's assertion.

According to Claydon, the electrostatic actuator is used to deform or tilt the CCR 306, **not** the static surfaces "310, 312, 314" (paragraph [0041], ll. 9-10 of Claydon). Why does the Examiner allege that Claydon's electrostatic actuator discloses the "micromechanical device" as recited in Claim 1 when Claydon's electrostatic actuator moves the entire CCR 306, not any of the individual surfaces "310, 312, 314"?

Although the Examiner uses Ibsen to show that it would have been allegedly obvious to modify Claydon's electrostatic actuator, Applicants submit that there is no motivation in the prior art to combine the cited references as asserted by the Examiner.

Applicants respectfully submit that there is no suggestion or motivation on the face of either Claydon or Ibsen for their combination nor any teaching as to how the features of the two devices could be combined so as to meet the structure as claimed in the present application. It has been found that "when the incentive to combine the teachings of the references is not readily apparent, it is the duty of the examiner to explain why combination of the teachings is proper. ... Absent such reasons or incentives, the teachings of the references are not combinable" Ex parte Skinner, 2 USPQ2d 1788 (B.P.A.I. 1986). Applicants submit that the Examiner's combination of Claydon and Ibsen is based upon a hindsight reconstruction of Applicants' claims as opposed to what the references really suggest.

Claydon discloses an electrostatic actuator that is used to move the CCR 306. Contrary to Claydon, Ibsen discloses a switching device 1116 that is able to move an individual mirror. The Examiner asserts that it would have been obvious to one having ordinary skill in the art to modify Claydon with Ibsen's switching device 1116.

Applicants submit that one skilled in the art would not find any suggestion or motivation in the cited references as a whole to combine or modify the two devices disclosed in the cited references to meet the structure as claimed in the present application.

Claydon already discloses an electrostatic actuator. Why would one skilled in the art include a switching device 1116 in Claydon when Claydon already discloses the electrostatic actuator? Applicants submit that the only reason these references were cited was because the Examiner used the present claims as a road map.

As stated by the Federal Circuit: "[i]t is impermissible to use the claimed invention as an instruction manual or 'template' to piece together the teachings of the prior art so that the claimed invention is rendered obvious. One cannot use hindsight reconstruction to pick and choose among isolated disclosures in the prior art to depreciate the claimed invention." In re Fritch, 972 F.2d 1260. Therefore, Applicants submit that the Examiner has failed to establish a *prima facie* case of obviousness for the claims rejected under 35 U.S.C. §103(a) and Applicants respectfully request that the rejection be withdrawn and claims allowed.

Applicants further submit that, even if it was possible to somehow combine the cited references, there is no evidence that the modified device would be satisfactory for its intended purpose.

According to MPEP §2143.01, if "proposed modification would render the prior art invention being modified unsatisfactory for its intended purpose, then there is no suggestion or motivation to make the proposed modification. *In re Gordon*, 733 F.2d 900, 221 USPQ 1125 (Fed. Cir. 1984)."

The Examiner alleges that it would have been obvious to place Ibsen's switching device 1116 in Claydon.

As stated above, Claydon's electrostatic actuator that is used to move the CCR 306, not the individual static surfaces "310, 312, 314." By placing the switching device 1116 in

Claydon to move one of the static surfaces "310, 312, 314" one skilled in the art would render Claydon's invention unsatisfactory for its intended purpose.

For the reasons set forth above, Applicants submit that the Examiner has failed to establish a *prima facie* case of obviousness of the claims rejected under 35 U.S.C. §103(a). Therefore, Applicants respectfully request that the rejection be withdrawn and claims allowed.

Applicants finally submit that a prima facie case of obviousness has not been established because Claydon and Ibsen teach away from their combination.

According to MPEP §2143.01, "where the teachings of two or more prior art references conflict, the Examiner must weigh the power of each reference to suggest solutions to one of ordinary skill in the art, considering the degree to which one reference might accurately discredit another. *In re Young*, 927 F.2d 588, 18 USPQ2d 1089 (Fed. Cir. 1991)."

As stated above, Claydon discloses stationary surfaces "310, 312, 314." On the contrary, Ibsen discloses a switching device 1116 for moving a reflective surface. Why would one skilled in the art place a reflective surface switching device 1116 into a reference that already discloses stationary surfaces "310, 312, 314"? The teachings are in opposition. Applicants submit that the Examiner's combination of Claydon and Ibsen is based upon a hindsight reconstruction of Applicants' claims as opposed to what the references really suggest. Applicants submit that the Examiner has failed to establish a prima facie case of obviousness. The combination of the cited references is improper because they teach away from their combination. Therefore, Applicants respectfully request that the rejection be withdrawn and claims allowed.

Claims 2 and 5

Claims 2 and 5, at least based on their dependency on Claim 1, are also believed to be patentable over Claydon and Ibsen.

Claim 6

Applicants submit that the Examiner has not shown that Claydon and Ibsen disclose, suggest or teach, *inter alia*, the following features recited by Claim 6 of the present application:

> "a micromechanical device for moving the **moveable grating structure** relative to the substrate" (emphasis added)

Although the Examiner concedes that this feature is not taught by Claydon, the Examiner alleges that it is disclosed by Ibsen (p. 4, ll. 8-15).

The Examiner asserts that the "moveable grating structure" as recited in Claim 1 is disclosed by Ibsen's gratings "214 and 216" (p. 4, l. 13). Applicants respectfully traverse the Examiner's assertion.

According to Ibsen's Figure 2 reproduced below, the gratings "214 and 216" are etched into the substrate 200 (column 7, ll. 17-18 of Ibsen).

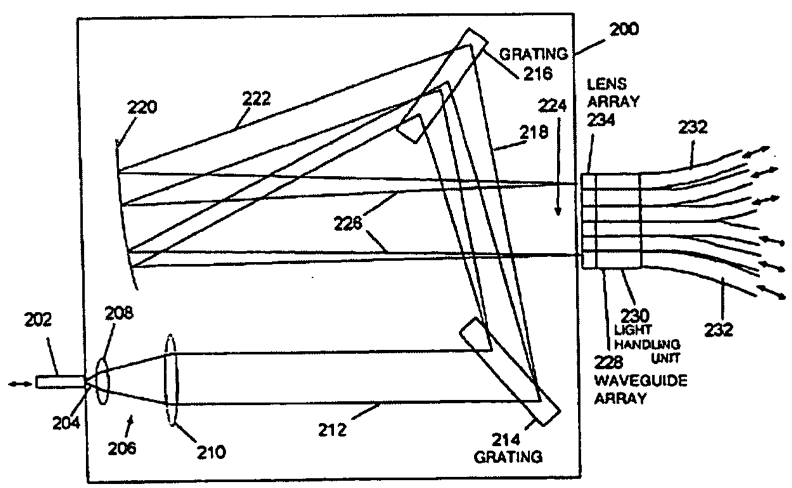


FIG. 2

Contrary to the Examiner's assertions, only reflective surfaces 1118 and 1518 are movable by switching device 1116, not the gratings "214 and 216," as shown in Ibsen's Figures 14A, 14B, 17A and 17B, reproduced below.

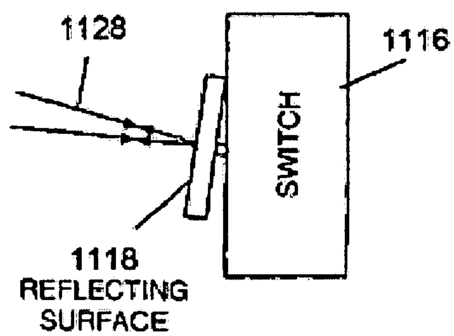


FIG. 14A

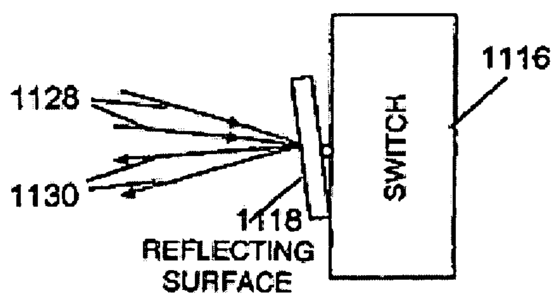


FIG. 14B

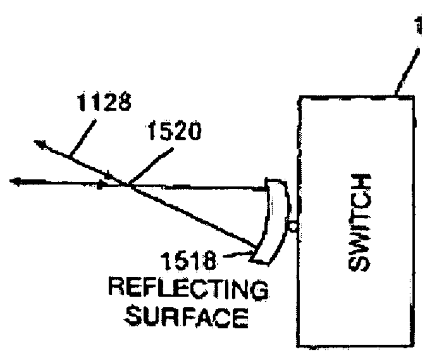


FIG. 17A

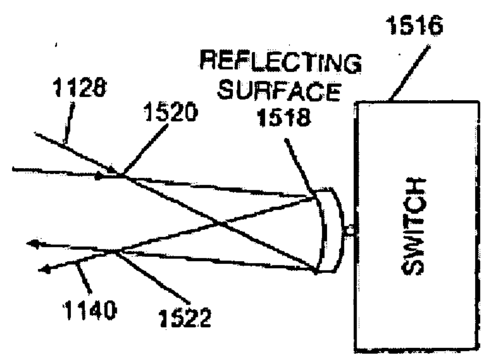


FIG. 17B

Why does the Examiner believe that Ibsen's gratings "214 and 216" disclose "moveable grating structure" as recited in Claim 6, when Ibsen's gratings "214 and 216" are etched into the substrate and are **not** movable?

Applicants submit that Ibsen does not teach, disclose or suggest "moveable grating structure" as recited in Claim 6, because Ibsen's gratings "214 and 216" are etched into

the substrate and are **not** movable. Hence, Claim 6 is patentable over Ibsen and the rejection should be withdrawn.

Claims 7 and 9-11

Claims 7 and 9-11, at least based on its dependency on Claim 6, are also believed to be patentable over Ibsen.

Claim 22

A. Applicants submit that the Examiner has not shown that Claydon and Ibsen disclose, suggest or teach, *inter alia*, the following features recited by Claim 22 of the present application:

> "a first position in which the retro-reflecting structure retro-reflects the optical beam and having a second position in which the retro-reflecting structure does not retro-reflect the optical beam, the first and second positions being spaced by a **distance less than a wavelength of the optical beam**" (emphasis added)

Applicants submit that the Examiner failed to comply with 37 C.F.R. §1.104(c)(2) by not designating "as nearly as practicable" where Claydon or Ibsen disclose that "the first and second positions" are "being spaced by a **distance less than a wavelength of the optical beam**" (emphasis added) as recited in Claim 22. Applicants submit that neither Claydon nor Ibsen disclose "a distance less than a wavelength of the optical beam" as recited in Claim 22. Hence, Claim 22 is patentable over Claydon and Ibsen and the rejection should be withdrawn.

B. Applicants submit that the Examiner has not shown that Claydon and Ibsen disclose, suggest or teach, *inter alia*, the following features recited by Claim 22 of the present application:

> "a micromechanical device for moving said at least one moveable optical element in response to **a modulation signal** to thereby modulate the optical beam as a modulated retro-reflected beam" (emphasis added)

Applicants submit that the Examiner failed to comply with 37 C.F.R. §1.104(c)(2) by not designating "as nearly as practicable" where Claydon or Ibsen disclose "a modulation signal" as recited in Claim 22. Applicants submit that neither Claydon nor Ibsen disclose "a modulation signal" as recited in Claim 22. Hence, Claim 22 is patentable over Claydon and Ibsen and the rejection should be withdrawn.

Claims 23-26

Claims 23-26, at least based on its dependency on Claim 22, are also believed to be patentable over Claydon and Ibsen.

Patentability of new Claim 33

New Claim 33 recites "wherein the first reflective surface and the second reflective surface are parallel to each other in the first position and the second position." Applicant submits that at least this feature is not disclosed by the prior art cited by the Examiner. Hence, Claim 33 is patentable and should be allowed by the Examiner. Claim 34, at least based on its dependency on Claim 33, is also believed to be patentable.

Patentability of new Claim 35

New Claim 35 recites "wherein the moveable grating structure and the substrate are parallel to each other in the first position and the second position." Applicant submits that at least this feature is not disclosed by the prior art cited by the Examiner. Hence, Claim 35 is patentable and should be allowed by the Examiner.

Conclusion

In view of the above, reconsideration and allowance of all the claims are respectfully solicited.

The Commissioner is authorized to charge any additional fees which may be required or credit overpayment to deposit account no. 12-0415. In particular, if this response is not timely filed, then the Commissioner is authorized to treat this response as including a petition to extend the time period pursuant to 37 CFR 1.136 (a) requesting an extension of time of the number of months necessary to make this response timely filed and the petition fee due in connection therewith may be charged to deposit account no. 12-0415.

I hereby certify that this correspondence is being deposited with the United States Post Office with sufficient postage as first class mail in an envelope addressed to Mail Stop Amendment Commissioner for Patents P.O. Box 1450, Alexandria, VA 22313-1450 on

February 15, 2007
(Date of Deposit)

Stefanie Pallan
(Name of Person Signing)

(Signature)

February 15, 2007
(Date)

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Encls:
Partial copy of U.S. Patent 5,208,886 (1 pg);
Partial copy of U.S. Patent 5,062,684 (1 pg);
Partial copy of the Encyclopedia of Lasers and Optical Technology (3 pgs);
Postcard,

METHODS OF MAKING AN OPTICAL FIBER FILTER

This is a division of application Ser. No. 07/466,536 filed Jan. 17, 1990 now U.S. Pat. No. 5,062,684.

TECHNICAL FIELD

This invention relates to methods of making an optical fiber filter. More particularly, the invention relates to methods of making an optical fiber filter which is tunable over a desired range to provide a desired bandwidth.

BACKGROUND OF THE INVENTION

The economic advantages of transmitting information in the form of optical signals have been realized in commercial systems. In currently used optical transmission systems, the optical signals are converted to electronic ones before processing occurs. Such processing involves the use of standard electronic devices.

Designs for future optical communication systems go beyond the simple transmission of information on an optical carrier, and include the processing of signals while still in optical form. In the next generation of optical communication systems, it is envisioned that optical signals will be processed without conversion to electronic signals. Such optical processing will require optical devices which are analogous to those devices, such as amplifiers, modulators, filters, multiplexers, demultiplexers, for example, which are used for processing electronic signals.

An easily manufacturable optical filter having a bandwidth between about 100 MHz and a few tens of gigahertz with low insertion loss would be an important component in wavelength multiplexing as well as in many other applications. It appears that the most promising approach to such a device is a fiber Fabry-Perot interferometer which may be referred to as an FFP.

A Fabry-Perot interferometer is an optical device which can be used to process optical signals and includes two mirrors with a cavity therebetween. The Fabry-Perot interferometer is discussed in most of the classic texts and its operation is well understood. See, for example, Born & Wolf, *Principles of Optics*, MacMillan, 1959, pages 322-332. An exemplary Fabry-Perot structure comprises a region bounded by two plane, parallel mirrors. The structure exhibits low loss, that is, it passes only particular wavelengths, for which the cavity is said to be in resonance-a condition obtained by adjusting appropriately the cavity parameters. At resonance, the cavity passes a series of approximately equally spaced wavelengths. The spacing between these wavelengths, called the free spectral range (FSR) or tuning range of the cavity, is a function of the spacing between the mirrors and the index of refraction of the medium between the mirrors. The tuning range of a Fabry-Perot interferometer is equal to $c/2nl_c$ where l_c is used to designate the length of the cavity. Accordingly, the shorter the cavity, the larger the tuning range. The bandwidth is largely determined by the reflectivity of the mirrors; however, other sources of loss and reflections can affect bandwidth. Another parameter which is designated finesse (F) is equal to the quotient of the tuning range divided by the bandwidth.

The use of Fabry-Perot cavities as filters, for example, to process optical signals is well known. However, the application of such devices to the processing of optical signals in commercial optical fiber communication systems has been hampered by, among other constraints, the lack of practical designs which have suitable characteristics, such as low loss when used with optical fibers and appropriate values of free spectral range. Nevertheless designs that more closely meet the needs of a commercial fiber system have been suggested. For example, in *Electronics Letters*, Vol. 21, No.11, pp. 504-505 (May 23, 1985), J. Stone discussed a fiber Fabry-Perot interferometer design in which the cavity was an optical fiber waveguide with mirrored ends. The free spectral range of the resulting cavity is determined by the length of the fiber segment. Accordingly different free spectral ranges can be obtained by using fiber segments of different lengths. The cavity can be tuned over one free spectral range by changing the cavity optical length by one-half the wavelength value of the light entering the cavity. In this way, the cavity can be tuned to resonate at, and therefore transmit light of different wavelength values. To obtain such tuning, the cavity length can be changed, for example, by means of a piezoelectric element attached to the fiber, which, when activated, will stretch the fiber and increase the associated cavity optical length accordingly. Fiber Fabry-Perot interferometers can be made with a finesse up to a value of 500 with relatively low insertion loss, using separately attached mirrors.

In an article entitled "Pigtailed High-Finesse Tunable Fiber Fabry-Perot Interferometers With Large, Medium and Small Free Spectral Ranges", authored by J. Stone and L. W. Stulz, appearing in the Jul. 16, 1987 issue of *Electronics Letters* beginning at page 781, the authors demonstrated that fiber Fabry-Perot interferometer devices with any required bandwidths can be fabricated from one of three types of structures reported in that article. Tuning is accomplished by stretching the fiber.

A so-called Type 1 structure reported in the above-identified article by Stone and Stulz is a fiber resonator. Mirrors are deposited on both ends of a continuous fiber and tuning is achieved by changing the optical length of the fiber. This type of fiber Fabry-Perot interferometer generally is limited to a length greater than 1 to 2 cm which equates to a free spectral range on the order of 10 to 5 GH_z. Although no alignment is required inside the cavity, the bandwidth range is limited to less than 100 MHz for a finesse of 100 and an l_c of 1 cm.

Among the advantages of the Type 1 Fabry-Perot interferometer is the fact that the cavity comprises an optical fiber which is a waveguide. This eliminates deleterious diffraction effects present in long Fabry-Perot cavities which are not waveguides. The elimination of the deleterious diffraction effects is associated with the guiding characteristics of the fiber. However, the difficulty of working with and stretching small lengths of optical fiber precludes large values of free spectral range when using a Type 1 Fabry-Perot. As a result, the usefulness of the Type 1 Fabry-Perot design is somewhat limited.

A Type 2 fiber Fabry-Perot inteferometer is a gap resonator with mirrors deposited on adjacent end faces of two optical fibers. In this type of filter, the defraction loss between the fibers limits the resonator gap to less than 10 μm which corresponds to a free spectral range greater than 10,000 GH_z.

Large free spectral ranges can be obtained by using a Type 2 Fabry-Perot interferometer in which the cavity comprises a small gap. However, because of diffraction

OPTICAL FIBER FILTER

TECHNICAL FIELD

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An easily manufacturable optical filter having a bandwidth between about 100 MHz and a few tens of gigahertz with low insertion loss would be an important component in wavelength multiplexing as well as in many other applications. It appears that the most promising approach to such a device is a fiber Fabry-Perot interferometer which may be referred to as an FFP.

A Fabry-Perot interferometer is an optical device which can be used to process optical signals and includes two mirrors with a cavity therebetween. The Fabry-Perot interferometer is discussed in most of the classic texts and its operation is well understood. See, for example, Born & Wolf, *Principles of Optics*, MacMillan, 1959, pages 322-332. An exemplary Fabry-Perot structure comprises a region bounded by two plane, parallel mirrors. The structure exhibits low loss, that is, it passes only particular wavelengths, for which the cavity is said to be in resonance—a condition obtained by adjusting appropriately the cavity parameters. At resonance, the cavity passes a series of approximately equally spaced wavelengths. The spacing between these wavelengths, called the free spectral range (FSR) or tuning range of the cavity, is a function of the spacing between the mirrors and the index of refraction of the medium between the mirrors. The tuning range of a Fabry-Perot interferometer is equal to $c/2\, nl_c$ where l_c is used to designate the length of the cavity. Accordingly, the shorter the cavity, the larger the tuning range. The bandwidth is largely determined by the reflectivity of the mirrors; however, other sources of loss and reflections can affect bandwidth. Another parameter which is designated finesse (F) is equal to the quotient of the tuning range divided by the bandwidth.

The use of Fabry-Perot cavities as filters, for example, to process optical signals is well known. However, the application of such devices to the processing of optical signals in commercial optical fiber communication systems has been hampered by, among other constraints, the lack of practical designs which have suitable characteristics, such as low loss when used with optical fibers and appropriate values of free spectral range. Nevertheless designs that more closely meet the needs of a commercial fiber system have been suggested. For example, in *Electronics Letters*, Vol. 21, No. 11, pp. 504–505 (May 23, 1985), J. Stone discussed a fiber Fabry-Perot interferometer design in which the cavity was an optical fiber waveguide with mirrored ends. The free spectral range of the resulting cavity is determined by the length of the fiber segment. Accordingly different free spectral ranges can be obtained by using fiber segments of different lengths. The cavity can be tuned over one free spectral range by changing the cavity optical length by one-half the wavelength value of the light entering the cavity. In this way, the cavity can be tuned to resonate at, and therefore transmit light of different wavelength values. To obtain such tuning, the cavity length can be changed, for example, by means of a piezoelectric element attached to the fiber, which, when activated, will stretch the fiber and increase the associated cavity optical length accordingly. Fiber Fabry-Perot interferometers can be made with a finesse up to a value of 500 with relatively low insertion loss, using separately attached mirrors.

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Among the advantages of the Type 1 Fabry-Perot interferometer is the fact that the cavity comprises an optical fiber which is a waveguide. This eliminates deleterious diffraction effects present in long Fabry-Perot cavities which are not waveguides. The elimination of the deleterious diffraction effects is associated with the guiding characteristics of the fiber. However, the difficulty of working with and stretching small lengths of optical fiber precludes large values of free spectral range when using a Type 1 Fabry-Perot. As a result, the usefulness of the Type 1 Fabry-Perot design is somewhat limited.

A Type 2 fiber Fabry-Perot interferometer is a gap resonator with mirrors deposited on adjacent end faces of two optical fibers. In this type of filter, the defraction loss between the fibers limits the resonator gap to less than 10 μm which corresponds to a free spectral range greater than 10,000 GH$_z$.

Large free spectral ranges can be obtained by using a Type 2 Fabry-Perot interferometer in which the cavity comprises a small gap. However, because of diffraction losses, wider gap cavities are less practical, and therefore the Type 2 Fabry-Perot interferometer is not adequate for applications which require the smaller free

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Encyclopedia of LASERS and OPTICAL TECHNOLOGY

tical fiber. There are five basic types of interferometric fiber-optic sensor: Mach–Zehnder, Michelson, Fabry–Perot, Bragg, and the Sagnac. The latter is primarily used in the development of fiber-optic gyros and for this reason is not included in Table I. The Michelson uses two closely spaced single-mode optical fibers, where one optical fiber serves as a reference. The sensing region is localized between the mirrored ends of the two optical fibers (Fig. 5), and interference associated with changes in the strain or temperature of the structure modulates the intensity of light incident on the detector. The coupler acts to mix the light from the two optical fibers. The differential Mach–Zehnder fiber-optic sensor is primarily a transmissive-based interferometer that also involves two closely spaced optical fibers, where localization is achieved by the introduction of an additional element of length in the sensing optical fiber. If both the input and output interfaces are on the same side of a structure, the optical fibers form two closely spaced loops and the sensing region becomes the small difference in the length between these two loops.

A Fabry–Perot fiber-optic sensor involves a single monomode optical fiber with a sensing region defined by a cavity comprising two mirror surfaces that are parallel to each other and perpendicular to the axis of the optical fiber. A change in the optical path length between the mirrors leads to a shift in the frequencies of the cavity modes. In some ways the Fabry–Perot cavity represents the simplest interferometric sensor and has several very attractive features: the reference and sensing optical fiber are one and the same, up to the first mirror that constitutes the sensing region; it can form a single-ended configuration (see Fig. 6); it can be wavelength-multiplexed; there is no need for phase preservation in the connector to a structure; it is a very sensitive sensor and is capable of excellent spatial resolution with a well-defined sensing region.

Bragg reflection from a region of periodic variation in the core index of refraction can also form the basis of a fiber-optic sensor. In this system the spectrum of light reflected from the Bragg grating is in the form of a narrow spike with a center wavelength that is linearly dependent on the product of the wavelength of the periodic variation and the mean core

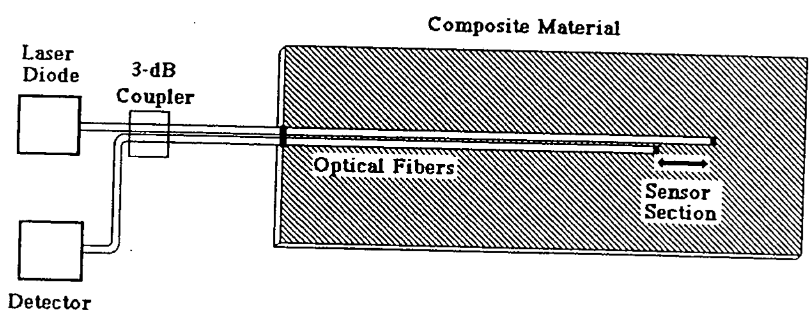

FIG. 5. Michelson interferometric fiber-optic sensor embedded within a composite panel.

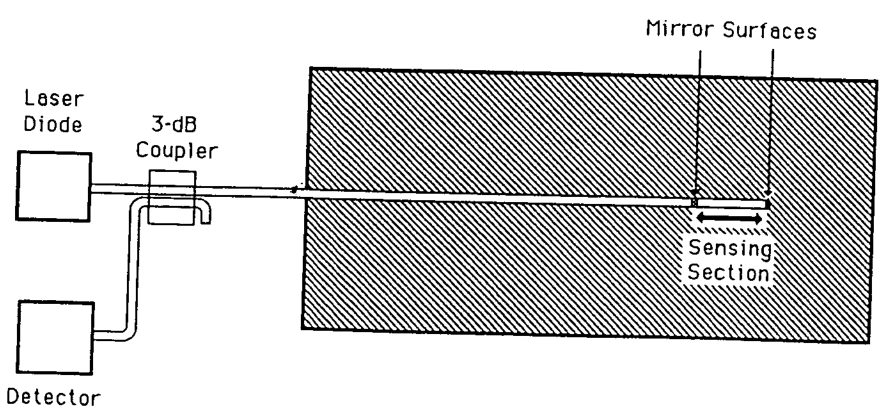

FIG. 6. Fiber-optic sensor based on a Fabry–Perot interferometer.

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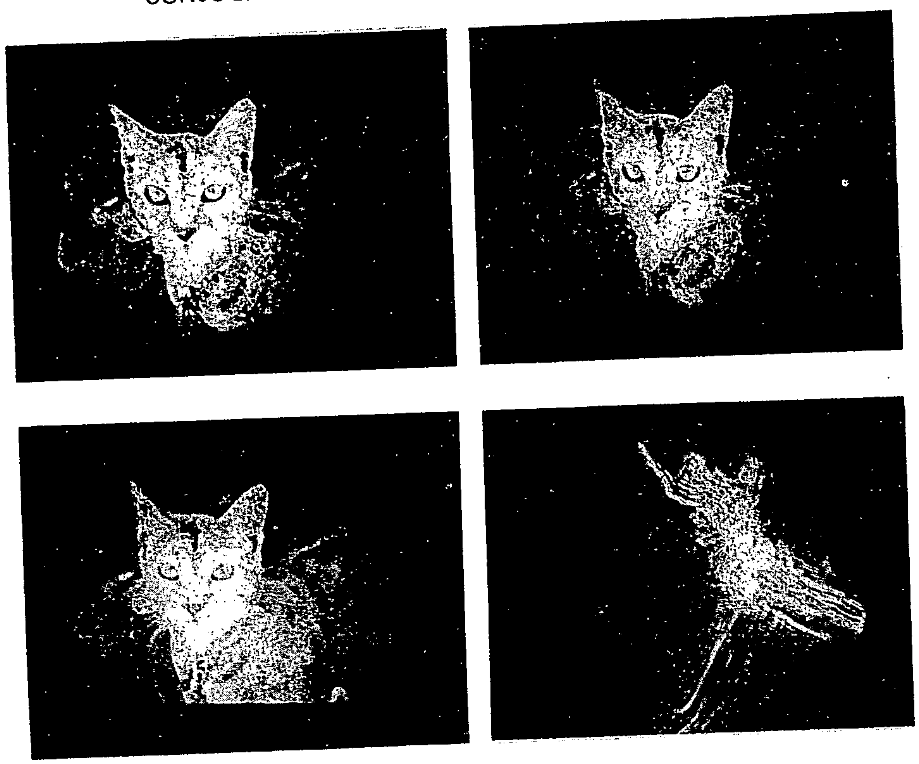

FIG. 40. Example of image reconstruction with phase conjugation. The unaberrated image is shown at the lower left using a plane mirror and at the upper left using a conjugate mirror. The image at the lower right shows the effect of an aberrator (a distorting piece of glass) on the image obtained with a normal mirror, while the image at the upper right shows the corrected image obtained with the aberrator and the conjugate mirror. [From J. Feinberg (1982). *Opt. Lett.* 7, 488. Copyright © 1982 by the Optical Society of America.]

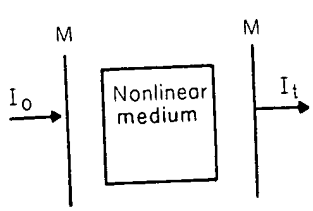

FIG. 41. Illustration of nonlinear Fabry–Perot cavity for optical bistability. The end mirrors are plane and parallel, and the medium in the center exhibits either a nonlinear refractive index or saturable absorption.

between the plates, and its reflection is high for other wavelengths.

The operation of a nonlinear FP cavity can be illustrated by assuming that the nonlinear medium has a refractive index that is a function of the intensity inside the FP cavity. The wavelength of the incident light is chosen to be off resonance so that at low incident intensities the reflectivity is high, the transmission is low, and not much light gets into the FP cavity. As the incident intensity is increased, more light gets